



# Fundamental Space Biology

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## **Cell Science Program Overview and Status**

2004 NASA Cell Science Conference

February 27, 2004

Nancy D. Searby

Fundamental Space Biology Program



# Fundamental Space Biology Program

## Changes in the past year

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NASA: From ReMaP to the Human Exploration Initiative

OBPR:

- New Leadership - Howard Ross, Dep Assoc. Administrator for Science  
Don Thomas, Chief Scientist for ISS

FSB Program:

- New Leadership - Gary Jahns, Manager of FSB Research Integration Office (RIO)
- '04 Flight research announcement released - emphasis on “model organisms”:
  - *Saccharomyces cerevesiae*
  - *Caenorhabditis elegans*
  - *Drosophila melanogaster*
  - *Arabidopsis thaliana*



# Bioastronautics Critical Path Roadmap (BCPR)

(Released: June 2003)

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- The BCPR identified 55 critical risks areas to human safety, health and performance in long-duration space flight missions.
- Data in each of these areas is needed in order to reduce risk to crew in support of NASA's Exploration Vision.
- Based on current rate of progress, and assuming 6 astronauts on orbit in ISS, it would take until 2038 to obtain statistically significant data on countermeasures for all these areas (B. Paloski, JSC).



# Cell Biology Research is Critical to Human Spaceflight

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- **Countermeasure Development**
  - **Animal testing of countermeasures can require large “n”:** Testing of one compound, at just 2 concentrations, with a minimum of 3 timepoints, 6 animals required per grouping = 36 animals plus controls = 72 animals for one relatively simple test, exclusive of gender and age testing.
  - Cell, tissue and microorganism studies will allow for large numbers of compounds to be screened, at varying concentrations, and understanding of underlying mechanisms may direct future compound choices.
- **Environmental Monitoring**
  - Cell and microorganism cultures can be used as sentinel populations to generate biologically relevant monitoring of radiation damage, and potential microgravity effects on cells.
- **Risk Assessment and Diagnosis**
  - Sentinels can be used to assess biologically relevant risks.
  - Mars and Lunar missions may require in flight diagnostics. Crew blood, urine and cell cultures can be processed and analysed using cell culture hardware.



# Cell and Tissue Culture Contribution to BCPR

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**Cell and tissue research can contribute to 16 out of 55  
risks in 6 of the 12 risk areas**

Risk area	Risk	
<b>2</b>		<b>Bone Loss</b>
	10	Fracture & impaired healing
	12	Renal stone formation
<b>3</b>		<b>Cardiovascular Mechanisms</b>
	13	Occurrence of serious cardiac dysrhythmias
	14	Impaired cardiovascular response to orthostatic stress
	15	Diminished cardiac function
	17	Impaired cardiovascular response to exercise stress
<b>4</b>		<b>Environmental Health</b>
	51	Inability to maintain acceptable atmosphere – environmental contaminants



# Cell and Tissue Culture Contribution to BCPR

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Risk area	Risk	
<b>7</b>		<b>Immunology, Infection, and Hematology</b>
	25	Altered wound healing
	26	Altered host-microbial interactions
	22	Immunodeficiency/infections
	23	Carcinogenesis caused by immune system changes
	24	Altered hemodynamic, cardiovascular dynamics – altered blood components
	27	Allergies and hypersensitivity reactions
<b>8</b>		<b>Muscle Alterations and Atrophy</b>
	28	Loss of skeletal muscle mass
	29	Inability to perform motor tasks
<b>10</b>		<b>Radiation Effects</b>
	38	Carcinogens caused by radiation



# FSB Cell Biology Grants Address Risk Areas

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	ISK DISCIPLINE AREA	Grants Addressing Risk Areas
1	Advanced Life Support	22
2	Power Loss	16
3	Cardiovascular Alterations	3
4	Environmental Health	
5	Food and Nutrition	
6	Human Behavior and Performance	3
7	Immunology, Infection and Hematology	27
8	Muscle Alterations and Atrophy	9
9	Neurovestibular Adaptation	4
10	Radiation Effects	7
11	Clinical Capabilities	
12	Ultisystem (Cross Risk) Alterations	5
	<b>Totals</b>	<b>96</b>



# Fundamental Space Biology Program

## 2003 - Center for Gravitational Biology Research

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• Supported 4 cell	biology studies.		
Sharmila Battacharia, Ph.D.	Lockheed Martin	<i>Drosophila Melanogaster</i> responses to hypergravity	1-Foot Diameter Centrifuge
James Thompson, Ph.D	University of Oklahoma	Effects of Hypergravity and Vibration on Genetic and Stability: Pilot Studies with <i>Drosophila Melanogaster</i>	1-Foot Diameter Centrifuge
Alan S. Waldman, Ph.D.	University of South Carolina	Effect of Gravity on DNA Transactions in Mammalian Cells	Low Vibration Rotation Device/Hypergravity Facility for Cell Culture
Steven Weinstein, Ph.D.	San Francisco State University	Effects of Centrifugation on the Immune Response of Macrophages	1-Foot Diameter Centrifuge
• Supported 2 cell	hardware studies.		
Rita Briggs, Ph.D.	Lockheed Martin Astrobiology and Space Research Services	In-situ Space Gene Expression on Nanosatellites (ISGEN): The Use of Yeast Constructs to Monitor the Space Environment	20-G Centrifuge
Justin Jagger	Space Station Biological Research Project	Cell Culture Unit Hardware Tests	Low Vibration Rotation Device/Hypergravity Facility for Cell Culture

For more information about how to access these facilities:  
<http://lifesci.arc.nasa.gov/CGBR/>





# Fundamental Space Biology Program

## 2003 Highlights - Workshops

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- **Free-flyer workshop**
- **Enterprise questions workshops**
- ***C. elegans*, *saccharomyces cerevisiae*, plant, and microbial workshops**
- **Pre-ASGSB Workshop - “What do you need to know about doing cell biology experiments in space?”**
- **Special interest subgroup at ASCB - “Gravity and Mechanotransduction Cell Signaling”**



# Fundamental Space Biology Program

## 2003 Highlights - Flight support

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### Ground-based activities:

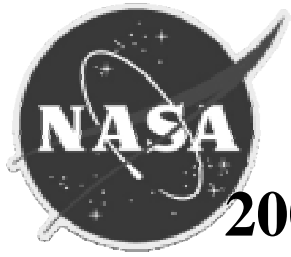
#### Small Payloads

- CEMSS-1 (*C. elegans* Model Specimens in Space) flight ready 6/04
- EMMYS-1 (Effect of Microgravity on Yeast Model Specimens, *S. cerevisiae*) flight ready 6/04
- PABS (*Pseudomonas aeruginosa* Bacteria in Space) PI : B. Pyle, flight ready 6/04

### Flight activities:

#### Small Payloads

- 13P: Launched 1/29/04,
  - Yeast-GAP, PI: C. Nickerson, Co-I: T. Hammond
  - Experiment successfully activated and completed, awaiting return.
- 8S: Soyuz Dutch Science Mission (DSM) DELTA Flight, Launch date 4/19/04
  - ICE-First, International *C. elegans* Experiment, PI: C. Conley
- 14P: Launch Date 5/21/04
  - Yeast-GAP II, PI: C. Nickerson, Co-I: T. Hammond

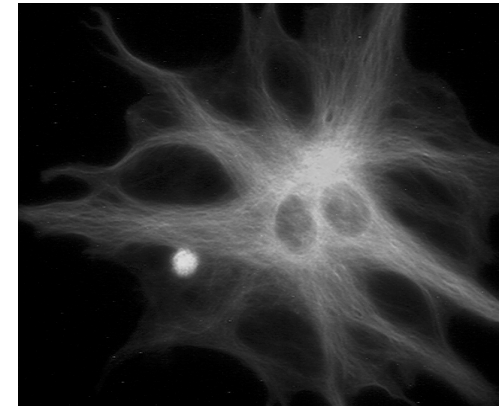


# Fundamental Space Biology Program

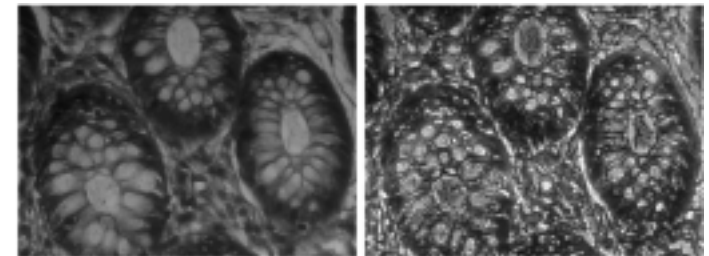
## 2003 Highlights - Cell Culture Unit (CCU) Flight hardware

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- **August 2003** - CCU System Critical Design Review (CDR) complete
- **September 2003** - Engineering Development Unit (EDU) added to program to support crew interface reviews, acoustic testing, thermal testing, sector level configuration, and Video Microscopy System (VMS)
  - Front panel complete Nov. 2003 - Reviewed by crew
  - Core unit complete Jan. 2004 - Acoustic testing in progress
- **October 2003** - Single Loop for Cell Culture (SLCC) program initiated
- **December 2003** - Safety and Crew Interface technical interchange meetings held at JSC
- **February 2004** - Software, Support Equipment, and Video Microscopy System (VMS) CDR complete



Fluorescence 20X



BrightField 20X

Phase Contrast 20X



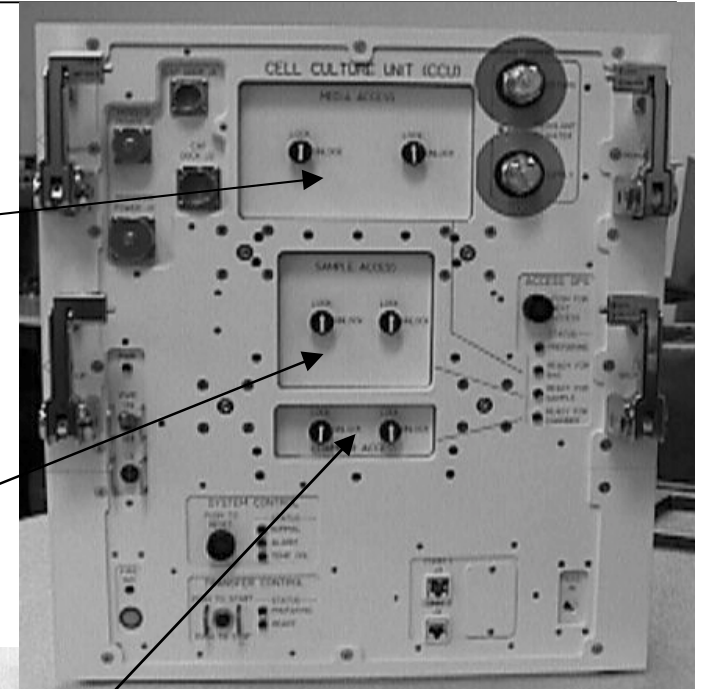
# CCU Flight Hardware Configuration

## Crew Accessible Items

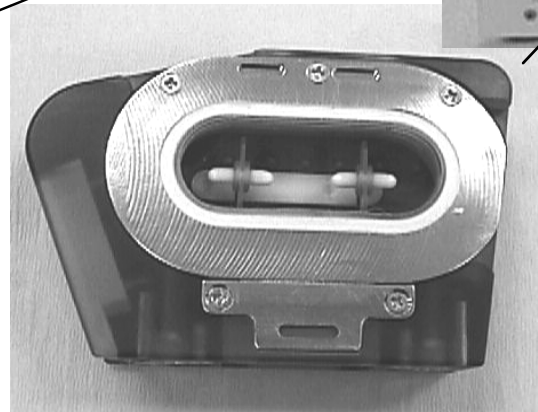
Media Bag Assemblies



Sample Containers



Engineering Development Unit

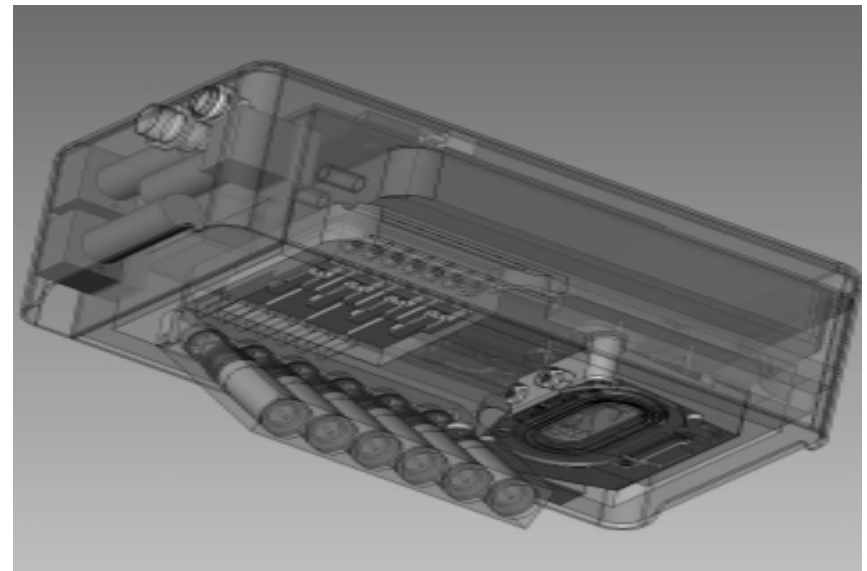
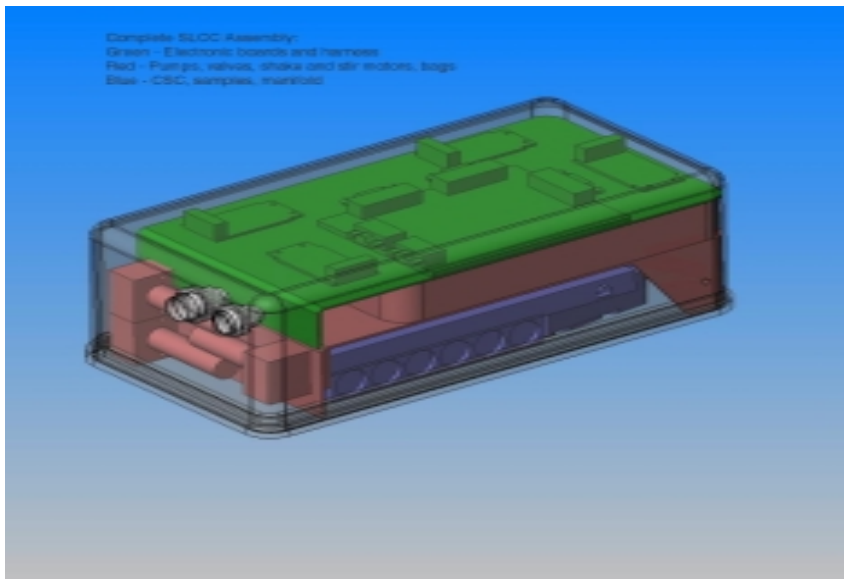


Cell Specimen Chambers



# Single Loop Cell Culture (SLCC)

- Single Loop for Cell Culture (SLCC) (10 flight units)
  - Flight implementation of CCU single loop concept
  - Performs perfusion, limited sampling, and fixation within sealed container
  - Flies in CGBA ICM or SSBRP Incubator
  - Rapid development for launch readiness in second half of 2004

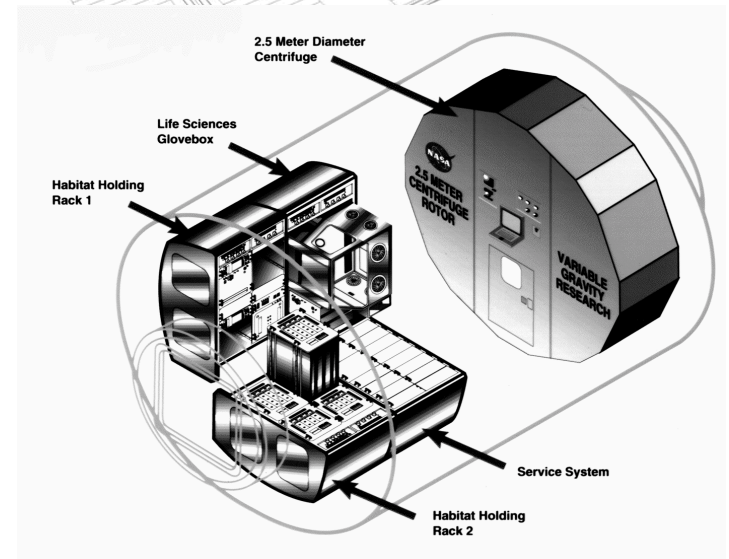
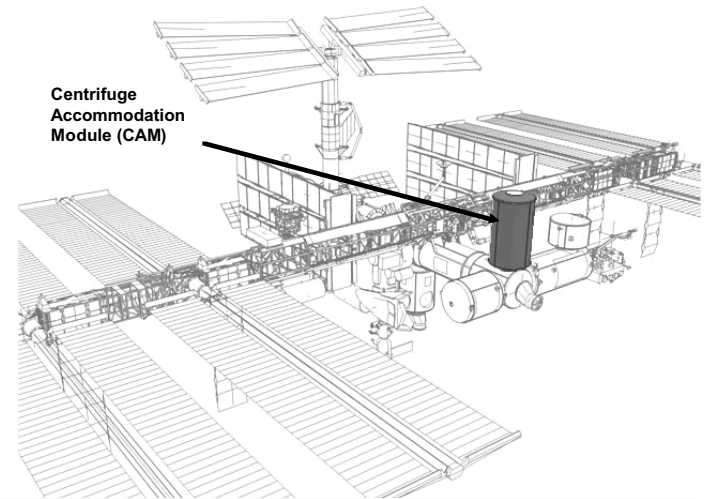




# Fundamental Space Biology

## 2004 Plan

- **Ground-Research:**
  - NRA: April/May release date
- **Flight:**
  - International Flight NRA: released 2/04, responses due 5/04
  - Upcoming Flights:
    - CEMSS-1 (*C. elegans* Model Specimens in Space) flight ready 6/04
    - EMMYS-1 (Effect of Microgravity on Yeast Model Specimens, *S. cerevisiae*) flight ready 6/04
    - PABS(*Pseudomonas aeruginosa* Bacteria in Space) PI : B. Pyle, flight ready 6/04
  - ISS SSBRP ongoing hardware development





# Feedback from Cell Science Questionnaires

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- Meeting now held over Saturday
- Contact information now included with program (in back).
- How to handle growth?
  - Parallel sessions vs. 4th day? 70% said parallel sessions
  - New question: parallel session vs. questionnaire
- Openness of meeting?
  - Presentations
  - Attendance
  - Publication of abstracts

***Please fill out questionnaire!***



**OBPR URL: [www.spaceresearch.nasa.gov](http://www.spaceresearch.nasa.gov)**

**Fundamental Space Biology:  
[www.fundamentalbiology.arc.nasa.gov/](http://www.fundamentalbiology.arc.nasa.gov/)**





# Fundamental Space Biology Program

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## **Backup charts**

